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Effects of trait and state anxiety levels (low, medium, and high) and response modes (reading, covert, modified multiple choice, constructed response) on posttest achievement for familiar and technical materials dealing with heart disease were investigated. Learning materials were presented to 148 subjects via computer-assisted instruction. High trait anxiety was associated with high state anxiety for all groups. Constructed response and reading groups performed significantly better than covert and multiple choice groups on technical but not familiar materials. However, the constructed response group had higher levels of state anxiety and longer learning times than other response mode groups. (Author)

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TECH MEMO

EFFECT OF ANXIETY, RESPONSE MODE, AND SUBJECT MATTER FAMILIARITY ON ACHIEVEMENT IN COMPUTER-ASSISTED LEARNING

Barbara L. Leherissey, Harold F. O'Neil, Jr.
and Duncan N. Hansen

Tech Memo No. 41
August 10, 1971

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Duncan N. Hansen
Director
CAI Center

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ABSTRACT

Barbara L. Leherissey, Harold F. O'Neil, Jr.
and Duncan N. Hansen

Florida State University

Effects of trait and state anxiety levels (low, medium, high) and response modes (reading, covert, modified multiple choice, constructed response) on posttest achievement for familiar and technical materials dealing with heart disease were investigated. Learning materials were presented to 148 subjects via computer-assisted instruction. High trait anxiety was associated with high state anxiety for all groups. Constructed response and reading groups performed significantly better than covert and multiple choice groups on technical but not familiar materials. However, the constructed response group had higher levels of state anxiety and longer learning times than other response mode groups.

EFFECT OF ANXIETY, RESPONSE MODE, AND SUBJECT MATTER FAMILIARITY ON ACHIEVEMENT IN COMPUTER-ASSISTED LEARNING[1]

Barbara L. Leherissey, Harold F. O'Neil, Jr., and Duncan N. Hansen

Florida State University

The purpose of the present study was to examine the process of anxiety within a computer-assisted learning situation involving covert and overt responding on problem-solving materials. Two theories which provide the conceptual framework within which research on anxiety and CAI learning can be examined are Spielberger's Trait-State Anxiety Theory and Spence-Taylor Drive Theory. According to Spielberger (1966), state anxiety (A-State) refers to a transitory state or condition that is characterized by feelings of tension or apprehension and heightened autonomic nervous system activity. Trait anxiety (A-Trait) implies individual differences in anxiety proneness, i.e., the disposition to respond with elevations in A-State under conditions that are characterized by some threat to self-esteem.

The Drive Theory of Spence (1958) and Taylor (1956) predicts that the effects of individual differences in anxiety (drive) level on performance will depend upon the relative strength of correct response and

[1]The authors wish to thank Dr. Sigmund Tobias for his assistance on the documentation of the learning program development, as well as his collaborative assistance in interpreting the present findings. This research was supported in part by a grant to the second author from the U.S. Office of Education (OEG-0-70-2671), and a contract to the third author from the Office of Naval Research (N00-14-68-A-0494). A paper based on this research was presented at the 1971 American Educational Research Association Meeting, New York, New York.

competing error tendencies. High drive would be expected to facilitate performance on simple learning tasks where the correct response is dominant, and to debilitate performance on difficult tasks where error tendencies are stronger. In research on Drive Theory, it is generally assumed that scores on the Taylor (1953) Manifest Anxiety Scale (TMAS) reflect individual differences in drive level. Spielberger (1966; Spielberger, Lushene, & McAdoo, In Press) has pointed out, however, that the TMAS seems to measure trait anxiety, while the concept of drive is logically more closely associated with state anxiety.

Several recent CAI studies have examined anxiety in the situation (A-State) and have supported the contention that periodic A-State measures are needed to understand the relationship between anxiety and performance (Leherissey, O'Neil, & Hansen, In Press; O'Neil, Spielberger, & Hansen, 1969; O'Neil, Hansen, & Spielberger, 1969). These studies used the State-Trait Anxiety Inventory (STAI) developed by Spielberger, Gorsuch, and Lushene (1970) to measure A-State during the learning of mathematical materials presented via CAI. High A-State students were found to make more errors on the difficult portion of the learning task than low A-State students, and to do as well as low A-State students on the easier portion of the task (O'Neil, Spielberger, & Hansen, 1969; O'Neil, Hansen, & Spielberger, 1969). In none of these CAI studies was level of A-Trait found to be related to performance. Thus, the results support both State-Trait Anxiety Theory and Drive Theory.

Generalizations from these CAI studies, however, have been based on the use of a single set of mathematical learning materials. To test the generality of these findings, verbal and graphical learning materials,

revised by Tobias (1968) for programmed instruction (PI) presentation, were coded for computer presentation. These materials dealt with two types of content: (a) familiar materials concerning the incidence and risk of contracting heart disease; (b) technical materials concerning the diagnosis of myocardial infarction. The latter materials required either verbal or graphic responses and were assumed to be unfamiliar to subjects.

Tobias (1968, 1969) investigated interactions between individual difference variables, two response modes to PI, and degree of familiarity with these materials. He found that the constructed response (CR) mode led to superior performance compared to the reading (R) mode on technical, unfamiliar materials; whereas, there were no significant differences on familiar materials.

The present study sought to investigate the effects of both state and trait anxiety on the CAI performance of students presented two forms of the technical graphical material used by Tobias (1968): a constructed response (CR) version in which subjects constructed graphics on the computer, and a reading (R) version which was similar to that used by Tobias. In addition, two other response modes were used: a modified multiple choice (MMC) version and a covert (C) version. The State-Trait Anxiety Inventory (STAI) was used to measure both A-Trait and A-State.

On the basis of Trait-State Anxiety Theory, Drive Theory, and Tobias' (1968) findings, the following predictions were made: (a) High A-Trait (HA) subjects would have higher levels of A-State throughout the task than low A-Trait (LA) subjects; (b) Since A-State has not been measured in any response mode study, no predictions were made concerning A-State levels

in the four response modes; (c) High A-State subjects would make fewer correct responses on the achievement measures than low A-State subjects; (d) the CR group would make more correct responses on the technical portion of the posttest and the R group would make the lowest number of correct responses, whereas, the C and MMC groups would make an intermediate number of correct responses; and (e) response mode groups would differ in total time on the learning materials.

Method

Subjects

The subjects were 148 female undergraduate students at Florida State University. These subjects were enrolled in psychology and health education classes in which participation in a learning experiment was a course requirement. The subjects were run in small groups of 8 to 15 subjects; a total of 15 experimental sessions was required to run all groups of subjects. The subjects were randomly assigned to one of four experimental conditions, Reading (R), Covert (C), Modified Multiple Choice, (MMC), or Constructed Response (CR), on the basis of their level of A-Trait, high (HA), medium (MA), or low (LA). The means and standard deviations for the A-Trait data obtained prior to the experiment on subjects subsequently assigned to the four experimental conditions are presented in Table 1. It may be noted that LA, MA, and HA subjects across response mode treatments are well-matched on A-Trait scores.

Apparatus

An IBM 1500 system (IBM, 1967) was used to present the learning materials. Terminals for this system consist of a cathode ray tube (CRT),

TABLE 1

Mean A-Trait Scores for LA, MA, and HA

Students in Response Mode Conditions

Groups	A-Trait Level Low (LA)	Medium (MA)	High (HA)
All Groups (N=148)			
Mean	27.82	37.19	47.73
SD	3.13	1.86	5.29
Reading (n=37)			
Mean	28.00	37.56	48.60
SD	3.98	1.77	4.99
Covert (n=37)			
Mean	27.91	37.44	46.40
SD	3.36	1.90	5.60
Modified Multiple Choice (n=37)			
Mean	27.82	36.69	47.60
SD	2.44	1.96	6.79
Constructed Response (n=37)			
Mean	27.55	37.06	47.10
SD	3.01	1.84	4.01

a light pen, and a typewriter keyboard. The terminals were located in a sound-deadened, air-conditioned room. The STAI A-State scales were presented on the CAI system in order to measure A-State while subjects worked through the learning materials. The CAI system recorded all subjects' responses, including response latencies.

Learning Materials and Program Description. The instructional program used by Tobias (1968), entitled Diagnosis of Myocardial Infarction, was presented via CAI. An effort was made to simulate Tobias' PI version with the minimum adaptations required to program the material in the Coursewriter II language. The learning materials and posttest were divided into two sections: (a) Familiar (F) material, with which subjects were expected to have previous familiarity; (b) Technical (T) materials, with which it was assumed that subjects had no previous exposure. These technical materials consisted of:(a) Technical Verbal materials, which required verbal responses, i.e., words; and (b) Technical Pictorial materials, which required pictorial responses, i.e., simulated drawings.

The F material in the learning program consisted of 56 frames which dealt with such topics as the incidence and prevalence of heart disease, the role of various risk factors in increasing the probability of heart disease, and the fatalities resulting from coronary disease. There were 89 frames of technical materials which dealt with the diagnosis of myocardial infarction, types of damage to the heart muscle, and their associated electrocardiogram (EKG) tracings. These learning materials are described in detail by Tobias (1968).

The basic learning program was divided into four versions, each containing exactly the same subject matter and frame structure. These four versions were: (a) Reading (R) version, to which the subjects were not required to make any overt responses, but merely to read each frame successively. Response blanks were filled in and frames asking a question were presented in declarative form. The R version corresponded to the Reading version of Tobias' programmed text; (b) Covert (C) version

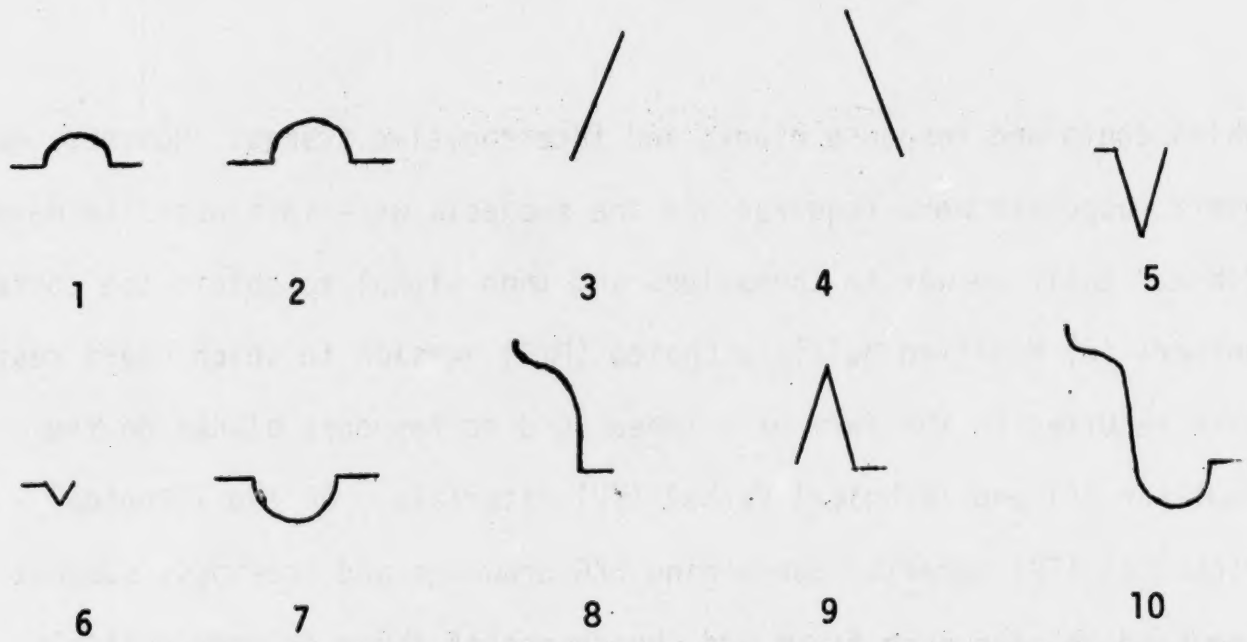
which contained response blanks and interrogative frames. However, no overt responses were required and the subjects were instructed to merely "think" their answer to themselves and then signal to obtain the correct answer; (c) Modified Multiple Choice (MMC) version to which overt responses were required in the form of a typed word to response blanks on the Familiar (F) and Technical Verbal (TV) materials. On the Technical Pictorial (TP) material containing EKG drawings and tracings, subjects were required to read each frame and choose one of three or four multiple choice answers before being shown the correct answer; (d) Constructed Response (CR) version which was identical to the MMC version on the F and TV frames, but to which subjects had to respond by "drawing" EKG tracings on the TP frames before receiving the correct answer.

The subjects constructed their graphic responses by special program coding which permitted them to construct successive parts of the drawings by various keyboard dictionary characters. Figure 1 illustrates how subjects in the CR group drew EKG tracings via CAI. For example if the subject was asked to draw the Normal EKG tracing, he referred to a handout of tracing segments (a), and chose the correct sequence of numbers which would construct this tracing (b). He then typed in these numbers one at a time and the normal EKG tracing would appear on the CRT (c). The special instructions and a further description of these program versions will be given in the procedure section.

Pre- and Posttests

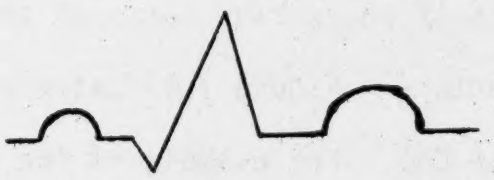
The pre- and posttests were the same as those used by Tobias (1968, 1969) and were administered to all subjects via paper and pencil. The pretest contained 17 items which covered the Familiar (F) learning materials.

A



B Correct sequence of numbers to "draw" Normal EKG tracing: 1, 6, 3, 4, 2

C



Normal EKG tracing

Figure 1. Illustration of how students in CR version "drew" EKG tracings via CAI.

The posttest was divided into two sections: (a) the 17 F items included in the pretest, and (b) 14 items which covered the Technical Verbal (TV) and Technical Pictorial (TP) materials. Both the pre- and posttests required constructed responses; for the TP items of the posttest, subjects were required to draw the appropriate EKG tracings and heart damage shadings.

Scoring of the pre- and posttest was based on the criteria set forth by Tobias (1968). Reported alpha reliabilities on the familiar portion of the posttest test was .66; on the technical portion, a reliability of .86 was reported; the reliability of the whole test was reported to be .82 (Tobias, 1968, 1969).

Anxiety Measures

The State-Trait Anxiety Inventory (STAI) (Spielberger, 1970) was used to measure both state and trait anxiety. The STAI A-Trait scale was used to select subjects with high (HA), medium (MA), and low (LA) levels of A-Trait. The 20-item A-Trait scale was administered with standard instructions, i.e., "indicate how you generally feel." The short form of the STAI A-State scale, which consisted of those five items having the highest item-remainder correlations with the normative sample of the 20-item STAI A-State scale, was administered a total of seven times during the experimental session.[2]

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[2]The five short-form STAI A-State items were: (a) "I am tense;" (b) "I feel at ease;" (c) "I am relaxed;" (d) "I feel calm;" (d) "I am jittery." Students responded to each item by rating himself on the following four-point scale; (a) "Not at all;" (b) "Somewhat;" (c) "Moderately so;" (d) "Very much so."

The short form A-State scale was given before and after the achievement pretest via paper and pencil; immediately before the learning materials, immediately following the familiar materials, immediately after the technical materials via CAI; and before and after the achievement posttest via paper and pencil. The A-State scales given before the achievement tests and before the beginning of the learning materials were presented with standard instructions, i.e., "indicate how you feel right now." The remaining A-State scales were presented with retrospective A-State instructions, i.e., "indicate how you felt during the task you have just finished." Each of the administrations of the A-State scale had randomly ordered item presentation from scale to scale.

Procedure

The experimental session was divided into three periods: (a) a Pretask period, during which subjects were administered the A-Trait scale, took the achievement pretest and its associated A-State scales, were assigned to response mode group, and read instructions on the operation of the CAI terminal; (b) a Performance Period, during which subjects learned Familiar, Technical Verbal (TV), and Technical Pictorial (TP) CAI materials and took three of the short form A-State scales; (c) a Posttask period, during which subjects were administered the achievement posttest, the final A-State measures, and given a debriefing. Each of these periods is further described below.

Pretask Period. Upon arrival at the CAI Center, subjects were administered the STAI A-Trait scale with standard instructions. This scale was collected and while being scored, subjects were given the Pretest package containing a short A-State scale to be completed prior to taking

the pretest, the 17-item pretest, and a second short A-State scale to be completed following the pretest. The subjects were then assigned to one of the four response mode conditions based on their A-Trait scores: (a) Reading (R), (b) Covert (C), (c) Modified Multiple Choice (MMC), or (d) Constructed Response (CR). The subjects then received written instructions on the operation of the CAI terminals.

Performance Period. All subjects were seated at CAI terminals and after "signing on" were presented with introductory materials dealing with the general nature of the experiment. The first short form A-State scale was then presented with standard instructions. Depending upon the response mode conditions to which subjects had been assigned, further instructions were given as to how they should proceed through the learning materials. All subjects were instructed to proceed through these materials at their own rate. Specific instructions given to each of the response mode groups were as follows:

Reading: "You will not be required to supply an answer to any of the frames. Simply press the space bar to continue on to the next frame. When you have finished the instructional material, you will be given a test on the material."

Covert: "You will not be required to supply an answer to any of the frames. However, you are to think the answer to yourself, then hit the space bar to see the correct answer. When you have finished the instructional material, you will be given a test on the material."

Both the MMC and CR groups received the following instructions for the F and TV materials.

"The material is presented in a series of frames, each of which requires you to give one or more answers. To answer each frame, you must type in the word or number that completes each blank and enter that response. On each frame of the material, when you have filled in all the blanks, the correct answer will appear on the screen before the next frame is presented. You will only be required to respond once to each frame, regardless of whether your answer is right or wrong. When you have finished the instructional material, you will receive a test on the material."

The MMC and CR groups were then given practice in the operation of the keyboard and were instructed on the enter and erase functions. On the TP materials, the MMC group was instructed to merely choose one of three or four alternatives by typing in the correct number; the CR group was given a handout of 10 possible EKG tracing segments and instructed to type in the combination of numbers from 0-9 which would complete the appropriate tracing (see a in Figure 1).

During this performance period, all subjects were presented the short form of the A-State scale with retrospective instructions immediately after the familiar materials and following the technical materials.

Posttask Period. After each subject had completed the instructional program and third CAI A-State scale, he "signed-off" the CAI terminal and was taken to another room in which subjects biographical data were collected. This took approximately 2 minutes after which subjects were given a posttest package containing the short A-State scale to be completed before the achievement posttest, the 31-item posttest, and the short A-State scale to be completed following the posttest.

After the completion of the posttest package, subjects were informed that the task was quite difficult and were reassured that their performance had been satisfactory. The subjects were also given some additional information concerning the general nature of the experiment, and cautioned not to discuss the experiment with their classmates.

Results

For the purpose of clarifying the presentation of findings in the present study, the results will be reported in the following order: (a) Anxiety Data during the Experimental Session; (b) Performance Data on Pre- and Posttest Achievement Measures; (c) Learning Time Data during the Instructional Materials; and (d) Performance Data on the Instructional Materials.

Anxiety Data

Effects of Response Modes on A-State For LA, MA, and HA Students

In order to investigate the relationships between levels of A-Trait and response modes on the seven A-State scores obtained during the experiment, the analyses were divided into three major periods. The first analysis focused on A-State measured before and after the pretest. The second analysis focused on A-State measured during the performance period, while the third analyzed A-State measured before and after the posttest. The cut-off scores for the LA and HA groups corresponded to the upper and lower quartiles of the published A-Trait norms for the college undergraduate females (Spielberger,et al., 1970.

The means and standard deviations of the seven A-State scores measured during the experiment for LA, MA, and HA students in the four response mode conditions are presented in Table 2. Three sets of three-factor analyses of variance with repeated measures on the last factor were calculated on this data. The independent variables in all three sets were levels of A-Trait (LA, MA, HA), response modes (R, C, MMC, CR), and the experimental time period in which A-State was measured.

Pretest A-State Analysis. The dependent variable in the first analysis was mean A-State scores before and after the pretest. Results of this analysis indicated that HA students had higher A-State scores ($\bar{X}$ = 12.04) than either MA ($\bar{X}$ = 9.21) or LA ($\bar{X}$ = 7.35) students. This main effect of A-Trait was significant at the $p < .001$ level ($F = 30.64$, $df = 2/136$). Students were also found to have higher mean A-State scores during the pretest ($\bar{X}$ = 9.92) than before the pretest ($\bar{X}$ = 8.93) ($F = 19.82$, $df = 1/135$, $p < .001$). No other main effects or interactions were significant.

Performance Period. In order to evaluate changes in A-State during the CAI learning task, the second analysis of variance evaluated changes in A-State during the performance period. Results of the analysis of variance on these data revealed two significant interactions: (a) response mode conditions by periods ($F = 2.60$, $df = 6/272$, $p < .05$); (b) A-Trait by periods ($F = 2.22$, $df = 4/272$, $p < .05$). The interaction between response mode conditions and periods is shown in Figure 2, which indicates that students had differential increases in A-State scores during the Technical instructional materials with the CR and MMC groups showing the greatest increase, whereas the R group remained relatively the same. The C group

TABLE 2

Mean A-State Scores for LA, MA, and HA Students in Response Mode Conditions During the Experiment

		Pretest Period		Performance Period		Posttest Period	
Groups		Before	After Pre	Familiar	Technical	Before	After
All groups (N=148)							
	Mean	8.93	9.92 - 10.16	9.20	10.63	9.69	11.11
	SD	3.40	3.68 3.28	3.01	4.09	4.17	4.76
READING							
	LA (n=11)						
	Mean	7.45	9.73 9.36	8.73	7.27	8.00	7.73
	SD	2.73	4.41 3.96	3.41	2.53	3.63	3.80
	MA (n=16)						
	Mean	8.88	9.19 8.63	8.31	8.63	8.31	9.94
	SD	4.24	3.12 3.26	3.40	3.01	3.14	4.45
	HA (n=10)						
	Mean	12.10	13.80 11.90	11.40	12.70	12.30	14.20
	SD	3.67	2.74 3.81	3.24	4.08	3.83	3.22
COVERT							
	LA (n=11)						
	Mean	7.45	7.00 7.36	7.18	7.91	7.73	8.18
	SD	3.11	1.73 2.11	1.89	3.42	3.44	2.93
	MA (n=16)						
	Mean	8.63	10.31 9.94	10.50	10.88	9.13	9.75
	SD	1.67	2.75 2.65	3.39	3.81	3.30	4.34
	HA (n=10)						
	Mean	10.40	12.60 11.80	10.20	11.80	9.60	10.80
	SD	2.80	3.66 13.46	1.93	3.58	2.55	4.98

TABLE 2--continued

Groups		Pretest Period Before	Pretest Period AFter	Performance Period Pre	Performance Period Familiar	Performance Period Technical	Posttest Period Before	Posttest Period After
MODIFIED MULTIPLE CHOICE								
LA (n=11)								
	Mean	5.91	7.73	8.91	8.45	9.27	8.18	11.18
	SD	1.45	3.20	3.33	4.11	4.36	3.84	5.06
MA (n=16)								
	Mean	8.50	9.06	10.31	7.81	10.81	8.81	11.19
	SD	2.71	2.91	2.91	3.54	4.37	3.37	3.60
HA (n=10)								
	Mean	12.60	13.60	13.70	10.50	12.80	11.90	12.20
	SD	2.72	4.03	3.13	1.65	4.57	4.95	5.03
CONSTRUCTED RESPONSE								
LA (n=11)								
	Mean	6.82	6.73	7.18	8.18	11.64	10.09	11.64
	SD	1.89	1.42	2.75	2.68	4.74	4.87	5.32
MA (n=16)								
	Mean	9.13	10.00	11.13	10.56	12.75	11.75	13.87
	SD	3.83	2.80	4.10	3.72	4.61	4.28	4.77
HA (n=10)								
	Mean	10.40	10.80	12.90	8.80	11.40	11.40	13.00
	SD	3.17	4.24	3.87	3.12	6.11	6.62	6.32

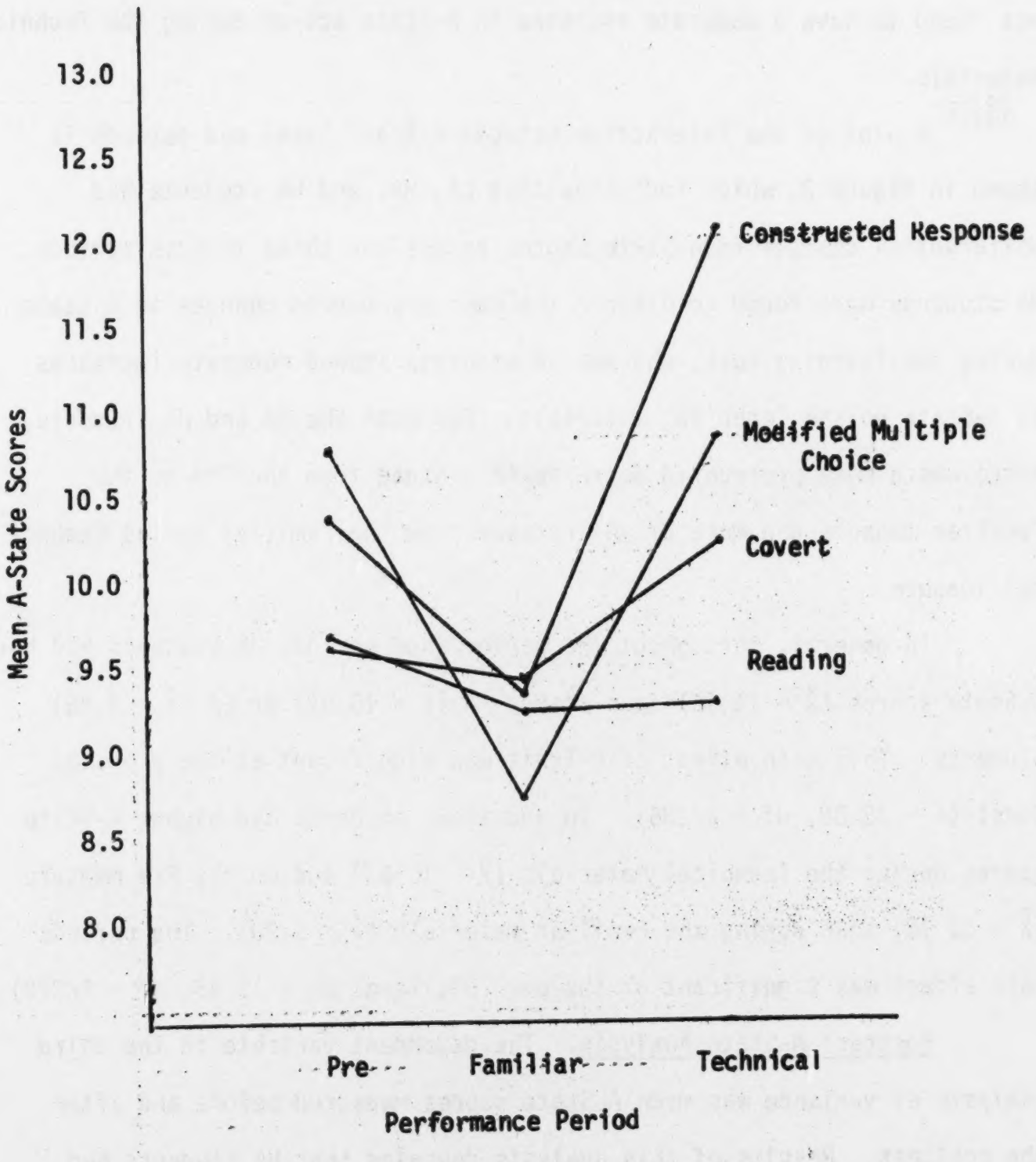

Figure 2. Mean A-State scores during performance period for students in the response mode condition.

was found to have a moderate increase in A-State scores during the Technical materials.

A plot of the interaction between A-Trait level and periods is shown in Figure 3, which indicates that LA, MA, and HA students had differential changes in A-State scores across the three in-task periods. HA students were found to exhibit the most pronounced changes in A-State during the learning task, whereas LA students showed moderate increases in A-State on the Technical materials. For both the MA and HA students, there was a more pronounced decrease in A-State from the Pre to the Familiar measure and more of an increase from the Familiar to the Technical measure.

In general, throughout the performance period, HA students had higher A-State scores ($\bar{X}$ = 11.66) than either MA ($\bar{X}$ = 10.02) or LA ($\bar{X}$ = 8.45) students. This main effect of A-Trait was significant at the $p < .001$ level ($F = 13.08$, $df = 2/136$). In addition, students had higher A-State scores during the Technical materials ($\bar{X}$ = 10.63) and on the Pre measure ($\bar{X}$ = 10.16) than during the Familiar materials ($\bar{X}$ = 9.20). The periods main effect was significant at the $p < .001$ level ($F = 11.46$, $df = 2/272$).

Posttest A-State Analysis. The dependent variable in the third analysis of variance was mean A-State scores measured before and after the posttest. Results of this analysis revealed that HA students had higher A-State scores ($\bar{X}$ = 11.92) than MA ($\bar{X}$ = 10.34) or LA ($\bar{X}$ = 9.09) students ($F = 5.35$, $df = 2/136$, $p < .001$). The main effect of periods was again highly significant ($F = 28.87$, $df = 1/136$, $p < .001$), indicating that students had higher A-State scores during the posttest ($\bar{X}$ = 11.11) than before the posttest ($\bar{X}$ = 9.69). In addition, an important finding was that students in the CR group had higher A-State scores ($\bar{X}$ = 12.07)

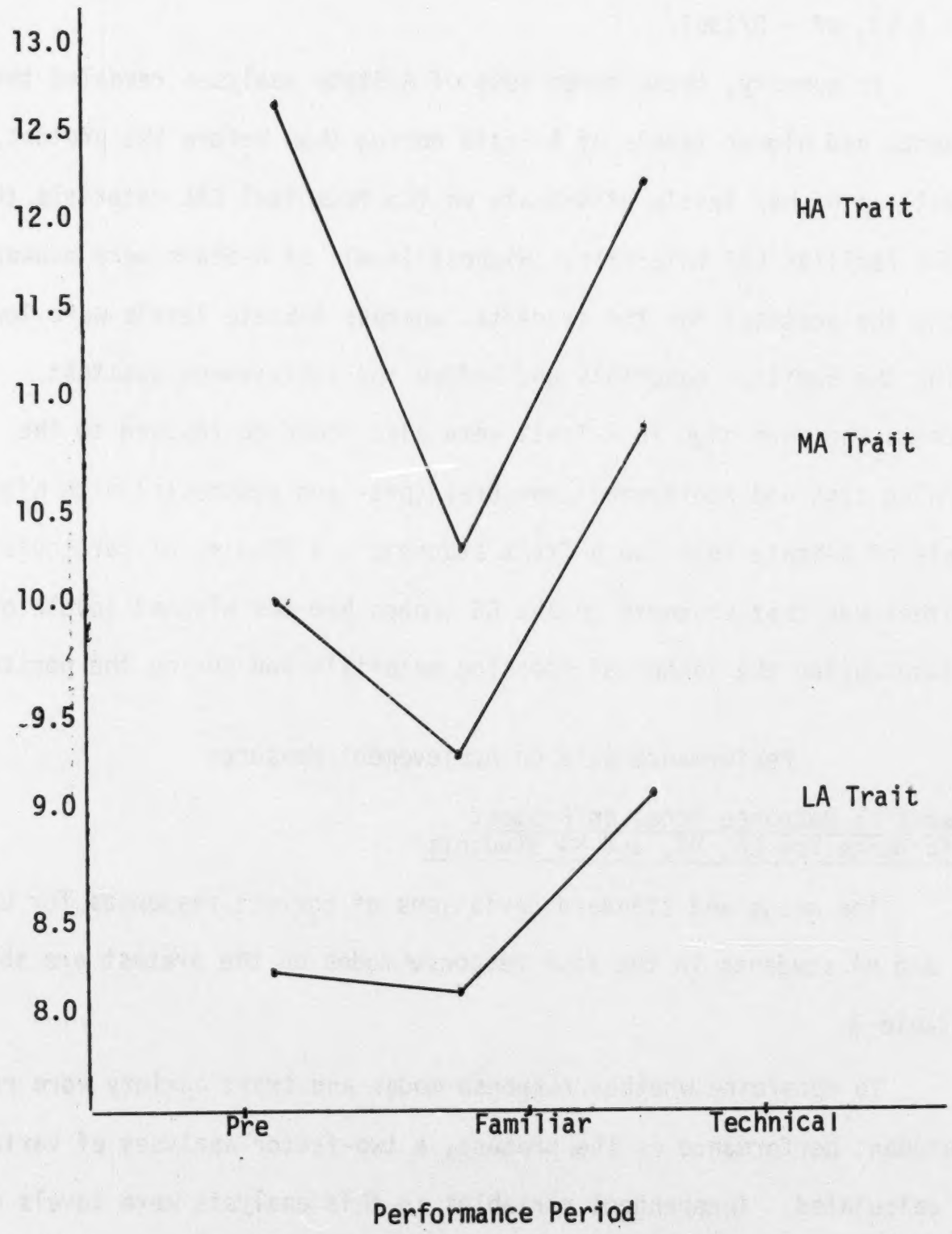

Figure 3. Mean A-State scores for LA, MA and HA students in the performance period.

than students in the MMC ($\bar{X}$ = 10.46), C ($\bar{X}$ = 9.20), or R ($\bar{X}$ = 9.86) groups. This main effect of Response Modes was significant at the $p < .05$ level ($F = 3.53$, $df = 3/136$).

In summary, these three sets of A-State analyses revealed that students had higher levels of A-State during than before the pretest, as well as higher levels of A-State on the Technical CAI materials than on the Familiar CAI materials. Highest levels of A-State were evoked during the posttest for the students, whereas A-State levels were lower during the Familiar materials and before the achievement posttest. Students who were high in A-Trait were also found to respond to the learning task and achievement measures (pre- and posttests) with higher levels of A-State than low A-Trait students. A finding of particular interest was that students in the CR groups had the highest levels of A-State during the Technical learning materials and during the posttest.

Performance Data on Achievement Measures

Effects of Response Modes on Pretest Performance for LA, MA, and HA Students

The means and standard deviations of correct responses for LA, MA, and HA students in the four response modes on the pretest are shown in Table 3.

To determine whether response modes and trait anxiety were related to student performance on the pretest, a two-factor analyses of variance was calculated. Independent variables in this analysis were levels of A-Trait (LA, MA, HA) and response modes (Reading, Covert, Modified Multiple Choice, Constructed Response). The dependent variable in this analysis

Table 3

Mean Correct Responses on the Pretest for LA, MA, and HA Students in Response Mode Conditions

Groups	A-TRAIT LEVEL Low (LA)	Medium (MA)	High (HA)
Reading (N=37)			
Mean	6.18	8.38	6.80
SD	3.66	3.48	3.62
Covert (N=37)			
Mean	8.18	8.12	7.00
SD	4.42	3.48	4.03
Modified Multiple Choice (N=37)			
Mean	9.36	7.69	6.60
SD	3.11	3.70	2.50
Constructed Response (N=37)			
Mean	9.18	8.00	9.50
SD	3.66	3.01	3.89

was mean number of correct responses on the pretest. Results of the analysis of variance on these data revealed no significant main effects or interactions, indicating that the groups were well-matched on prior knowledge of the instructional materials.

Effects of Response Modes on Pretest Performance for Low, Medium, and High A-State Students

Also of interest in the present study was whether response modes and state anxiety were related to student performance on the pretest. The means and standard deviations of correct responses on the pretest for low,

medium, and high A-State students in the four response modes are shown in Table 4.

Table 4

Mean Correct Responses on the Pretest for Low, Medium, and High A-State Students in Response Mode Conditions

Groups	A-STATE LEVEL Low	Medium	High
Reading (n=37)			
Mean	8.10	6.86	7.05
SD	2.81	2.19	4.35
Covert (n=37)			
Mean	6.57	8.76	6.67
SD	3.82	3.95	3.39
Modified Multiple Choice (n=37)			
Mean	9.27	7.36	7.25
SD	3.35	3.75	2.60
Constructed Response (n=37)			
Mean	9.33	8.83	7.57
SD	2.77	3.52	4.35

The independent variables in this analysis were levels of A-State during the pretest (low, medium, high) and the four response modes. The students were divided into low, medium, and high A-State groups by ranking the distribution of A-State scores on the retrospective A-State measure given after the pretest and dividing this distribution into thirds. The R, C, MMC, and CR students were then separated out of this distribution yielding an unequal but proportional N in each group. The range of low A-State scores was 5-7; medium A-State scores ranged from 8-11; the

range of high A-State scores was 12-20. The dependent variable in this analysis was mean number of correct responses on the pretest. As in the previous analysis, there were no significant main effects or interactions. Thus, these data indicate that neither level of state anxiety or response mode were related to pretest performance.

Effects of Response Modes on Posttest Performance for LA, MA, and HA Students

The means and standard deviations of correct responses on the Familiar and Technical portions of the posttest for LA, MA, and HA students in the four response mode conditions are presented in Table 5 and 6 respectively.

TABLE 5

Mean Correct Responses on the Familiar Posttest for Low, Medium and High A-Trait Students in Response Mode Conditions

Groups	A-TRAIT LEVEL Low	Medium	High
Reading (N=37)			
Mean	17.73	16.83	15.90
SD	2.24	2.58	2.51
Covert (N=37)			
Mean	16.91	14.81	12.50
SD	2.95	3.58	4.03
Modified Multiple Choice (N=37)			
Mean	15.91	16.69	18.00
SD	2.77	4.54	1.89
Constructed Response (N=37)			
Mean	16.00	13.81	16.60
SD	3.58	3.54	6.60

TABLE 6

Mean Correct Responses on the Technical Posttest for Low, Medium and High A-Trait Students in Response Mode Conditions

Groups	A-TRAIT LEVEL Low	Medium	High
Reading (N=37)			
Mean	65.27	59.25	53.80
SD	15.46	18.27	13.77
Covert (N=37)			
Mean	59.73	52.25	40.80
SD	18.07	20.65	27.80
Modified Multiple Choice (N=37)			
Mean	58.00	45.50	47.40
SD	16.53	8.58	17.83
Constructed Response (N=37)			
Mean	66.09	57.06	60.40
SD	15.18	22.68	22.58

In order to examine the effects of response mode conditions and trait anxiety on Familiar and Technical posttest performance, a set of two, two-factor analyses of variance were calculated on these data. Independent variables in these analyses were levels of A-Trait (LA, MA, HA) and response mode conditions (R, C, MMC, CR). The dependent variable in the first analysis was mean correct responses on the Familiar portion of the posttest, while mean correct responses on the Technical posttest was the dependent variable on the second analysis.

Results of the analysis on the Familiar posttest indicated that level of A-Trait and response mode conditions differentially affected performance. This A-Trait by response mode interaction was significant at the $p < .05$ level ($F = 2.48$, $df = 6/136$). As is shown in Figure 4, there was little difference for LA Ss in the four response mode conditions. Moreover, either medium or high A-Trait students performed more poorly if they were in the R or C groups. The HA students performed better in the MMC and CR groups. In addition, students in the R and MMC groups had more correct response ($\bar{X} = 16.57$; $\bar{X}$ 16.81 respectively) than students in the CR ($\bar{X} = 15.26$) or C group ($\bar{X} = 14.81$). This main effect of response modes was significant ($F = 3.56$, $df = 3/136$, $p < .05$).

Results of the analysis on technical posttest performance indicated that LA students performed better ($\bar{X} = 62.27$) than MA ($\bar{X} = 53.52$) or HA ($\bar{X} = 50.60$) students on the Technical posttest. This main effect of A-Trait was significant at the $p < .05$ level ($F = 4.67$, dr = 2/136). In addition, students in the CR ($\bar{X} = 60.65$) and R ($\bar{X} = 59.57$) groups performed better than students in C ($\bar{X} = 51.38$) and MMC ($\bar{X} = 49.73$) groups ($F = 3.28$, $df = 3/136$, $p < .05$). Both level of A-Trait and response mode conditions were, therefore, found to be related to Technical posttest performance.

Effects of Response Modes on Posttest Performance, for Low, Medium, and High A-State Students

Since previous CAI research (O'Neil, Spielberger, & Hansen, 1969; O'Neil, Hansen, & Spielberger, 1969; O'Neil, 1970; Leherissey, O'Neil, & Hansen, In Press) have shown a relationship between A-State, rather than A-Trait and learning performance, this relationship was examined in

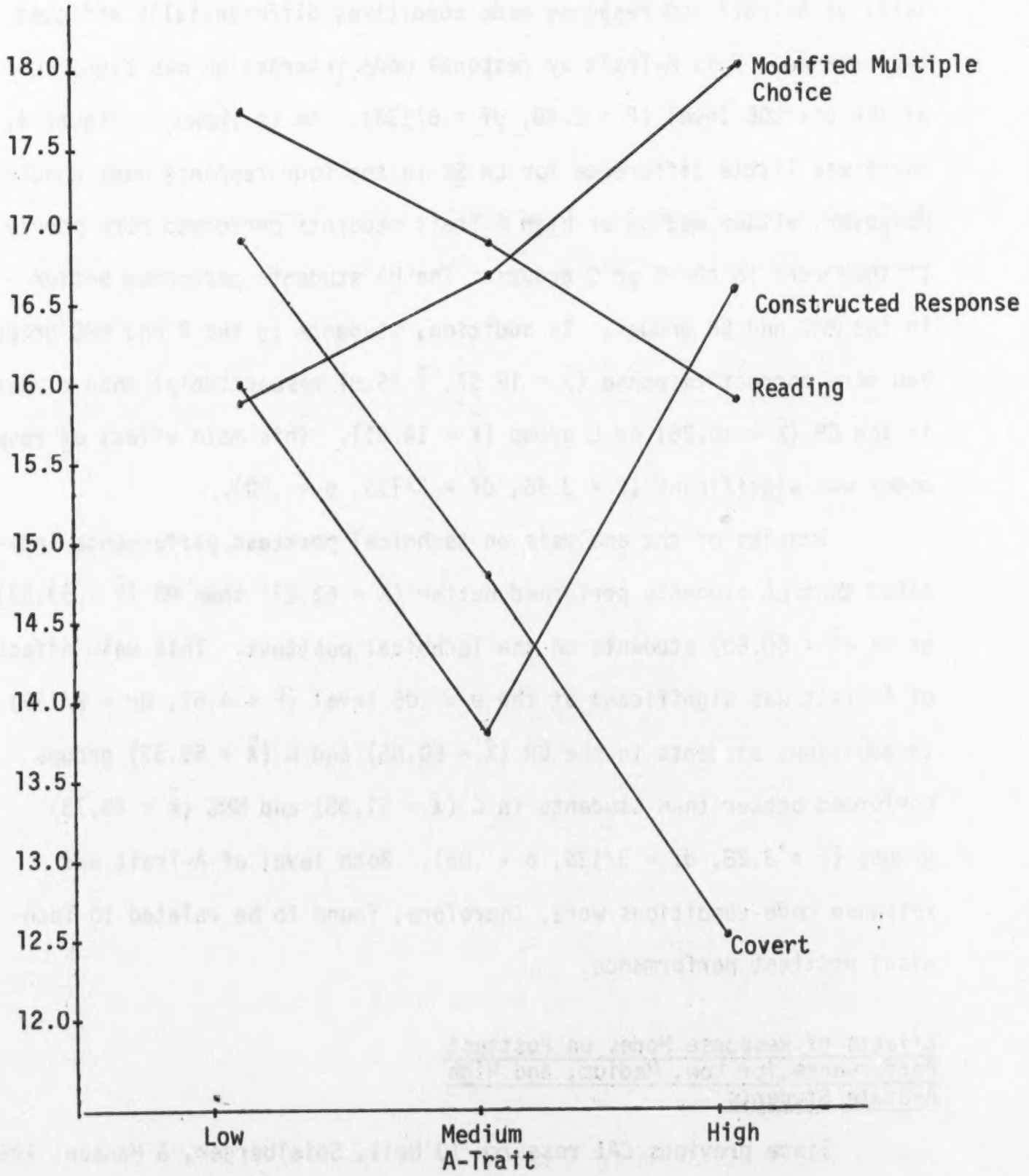

Figure 4. Mean correct responses on the F posttest for LA, MA and HA students in the response mode condition.

the present study. The means and standard deviations of correct responses on the Familiar and Technical portions of the posttest for low, medium, and high A-State students in the four response mode conditions are presented in Table 7 and 8 respectively.

TABLE 7

Mean Correct Responses on the Familiar Posttest for Low, Medium, and High A-State Students in Response Mode Conditions

Groups	A-STATE LEVEL Low	Medium	High
Reading (N=37)			
Mean	17.33	16.83	16.20
SD	2.38	2.55	2.70
Covert (N=37)			
Mean	15.17	14.33	14.71
SD	4.12	3.45	4.75
Modified Multiple Choice (N=37)			
Mean	17.09	16.40	17.09
SD	2.70	3.72	4.13
Constructed Response (N=37)			
Mean	18.38	14.92	13.88
SD	3.16	3.52	3.28

Two two-factor analyses of variance were calculated on these data. Independent variables in both analyses were levels of A-State during the posttest (low, medium, high) and response mode conditions (R, C, MMC, CR). Students were divided into low, medium, and high A-State groups by ranking the distribution of A-State scores on the retrospective A-State measure given after the posttest and dividing this distribution into thirds. The

TABLE 8

Mean Correct Responses on the Technical Posttest for Low, Medium, and High A-State Students in the Response Mode Conditions

Groups	A-STATE LEVEL Low	Medium	High
Reading (N=37)			
Mean	68.47	57.25	49.00
SD	16.45	12.52	14.58
Covert (N-37)			
Mean	52.56	50.42	50.00
SD	27.11	21.90	10.80
Modified Multiple Choice (N=37)			
Mean	50.27	52.67	45.18
SD	14.60	11.98	18.14
Constructed Response (N=37)			
Mean	70.00	57.38	58.63
SD	22.47	21.62	18.42

R, C, MMC, and CR students were then separated out of this distribution, yielding an unequal but proportional N in each group. The range of low A-State scores was 5-8; medium A-State scores ranged from 9-13; the range of high A-State scores was 13-20. The dependent variable in the first analysis was mean correct responses on the Familiar section of the post-test; mean correct responses on the Technical section of the posttest was the dependent variable in the second analysis.

Results of the analysis of variance on the Familiar posttest scores indicated that students in the R ($\bar{X}$ = 16.86) and MMC ($\bar{X}$ = 16.81) groups

had higher scores than the CR ($\bar{X}$ = 15.22) and C ($\bar{X}$ = 14.81) groups. This main effect of Response Mode Conditions was significant at the $p < .05$ level ($F = 2.97$, $df = 3/136$).

Results of the analysis of variance on the mean correct responses on the Technical portion of the posttest also revealed a main effect of Response Mode Conditions ($F = 3.53$, $df = 3/136$, $p < .05$). Students in the CR ($\bar{X}$ = 60.65) and R ($\bar{X}$ = 59.57) groups had higher scores on the Technical posttest than the C ($\bar{X}$ = 51.38) and MMC ($\bar{X}$ = 49.73) groups. As in the preceding analysis, no other main effects or interactions were significant. However, the main effect of A-State did approach significance ($F = 2.98$, $df = 2/136$, $p < .10$), with low A-State students making more correct responses ($\bar{X}$ = 59.35) than medium ($\bar{X}$ = 54.39) or high ($\bar{X}$ = 51.71) A-State students.

Learning Time Data

Effects of Response Mode Conditions on Total Learning Time for LA, MA, and HA Students

The means and standard deviations for mean learning time of LA, MA, and HA students in the four response mode conditions are presented in Table 9.

In order to determine whether students of different A-Trait levels in the four response mode conditions would differ in total time spent on the learning materials, a two-factor analysis of variance was calculated. The independent variables in this analysis were levels of A-Trait (LA, MA, HA) and response mode conditions (R, C, MMC, CR). The dependent variable in this analysis was mean number of minutes spent on the CAI learning task.

Table 9

Mean Learning Times for Low, Medium, and High A-Trait Students in the Response Mode Conditions

Groups	A-TRAIT LEVEL Low	Medium	High
Reading (n=37			
Mean	47.18	46.81	54.00
SD	18.69	16.74	30.94
Covert (n=37)			
Mean	67.91	68.81	58.90
SD	15.97	19.43	10.81
Modified Multiple Choice (n=37)			
Mean	104.73	104.38	101.60
SD	21.88	14.75	10.89
Constructed Response (n=37)			
Mean	100.73	113.69	120.30
SD	12.38	15.58	15.14

Results of the analysis of variance on these data indicated that students in the CR ($\bar{X}$ = 111.62) and MMC ($\bar{X}$ = 103.78) conditions took longer on the learning task than students in the R ($\bar{X}$ = 48.87) and C ($\bar{X}$ = 65.87) conditions. This main effect of Response Mode Condition was significant at the $p < .001$ level ($F = 103.33$, $df = 3/136$). Thus, level of A-Trait was not found to be related to total learning time, whereas there were significant differences in time spent on the learning task for students in the four response mode conditions.

Effects of Response Mode Conditions on Total Learning Time for Low, Medium, and High A-State Students

Another question of interest was the relationship between state anxiety, response mode conditions, and total time spent on the learning task. The means and standard deviations for mean learning times of low, medium, and high A-State students in the four response mode conditions are presented in Table 10.

Table 10

Mean Learning Times for Low, Medium, and High A-State Students in the Response Mode Conditions

Groups	A-STATE LEVEL Low	Medium	High
Reading (n=37)			
Mean	44.39	43.60	63.67
SD	15.76	8.46	33.91
Covert (n=37)			
Mean	65.25	66.81	65.00
SD	12.34	19.80	17.14
Modified Multiple Choice (n=37)			
Mean	102.92	103.80	104.57
SD	19.80	10.90	16.15
Constructed Response (n=37)			
Mean	101.67	109.00	117.15
SD	16.32	16.83	13.94

To examine this relationship, a two-factor analysis of variance was calculated. Independent variables in this analysis were levels of A-State during the Technical section of the learning materials (low, medium, high) and the four response mode conditions. The students were divided into low, medium, and high A-State groups by ranking the distribution of A-State scores during the Technical materials and dividing this distribution into thirds. The students in the R, C, MMC, and CR groups were then separated out of this distribution, yielding an unequal but proportional N in each group. The range of low A-State scores was 5-8; medium A-States scores ranged from 9-12; the range of high A-State scores was 13-20. Mean number of minutes spent on the CAI learning task was the dependent variable in this analysis.

Results of the analysis of variance on these data also indicated a significant main effect of Response Mode Conditions ($F = 91.52$, $df = 2/136$, $p < .001$). In addition, high A-State students ($\bar{X} = 97.35$) took longer on the task than either medium A-State students ($\bar{X} = 77.61$) or low A-State ($\bar{X} = 73.75$) students. This main effect of A-State was significant at the $p < .05$ level ($F = 3.46$, $df = 2/136$). Thus, level of A-State was found to be directly related to the amount of time spent on the learning task.

Although level of A-Trait was not related to total learning time, both level of A-State and Response Mode Conditions were related to time spent learning the instructional materials.

Performance Data on Instructional Program

Effects of Response Modes on Learning Program Performance for LA, MA, and HA Students

Of interest in the present study was a comparison of the performance of students differing in level of A-Trait who responded to the learning materials (the MMC and CR groups) on the CAI learning task. It should be recalled that neither the R nor C groups were required to respond to these materials. The means and standard deviations of correct responses on the Familiar and Technical materials for LA, MA, and HA students in the CR and MMC response mode conditions are presented in Tables 11 and 12, respectively.

TABLE 11

Mean Correct Responses on the Familiar Learning Materials for Low, Medium, and High A-Trait Students In Response Mode Conditions

Groups	A-TRAIT LEVEL Low	Medium	High
Modified Multiple Choice (n=37)			
Mean	67.36	67.25	65.00
SD	4.01	3.30	6.29
Constructed Response (n=37)			
Mean	66.82	67.19	67.80
SD	2.79	2.34	3.08

Table 12

Mean Correct Responses on the Technical Learning Materials for Low, Medium, and High A-Trait Students in the Response Mode Conditions

Groups	A-TRAIT LEVEL Low	Medium	High
Modified Multiple Choice (n-37)			
Mean	165.82	160.19	154.70
SD	9.65	16.13	26.93
Constructed Response (n=37)			
Mean	151.82	142.63	147.30
SD	19.93	24.86	16.04

Two two-factor analyses of variance were calculated on these data. The independent variables in both analyses were levels of A-Trait (LA, MA, HA) and response mode conditions (MMC, CR). The dependent variable in the first analysis was mean correct responses on the Familiar materials; mean correct responses on the Technical materials was the dependent variable in the second analysis.

Results of the analysis of variance on the Familiar materials revealed no significant main effects or interactions. The analysis of variance on the Technical materials, however, yielded a main effect of response mode conditions ($F = 7.56$, $df = 1/68$, $p < .01$). Students in the MMC group made more correct responses ($\bar{X} = 160.38$) than the CR group ($\bar{X} = 146.62$) on technical portion of the learning materials. Level of A-Trait was not found to be related to performance on the learning materials for the CR and MMC groups.

Effects of Response Modes on Learning Program Performance for Low, Medium, and High A-State Students

To test the assumption that state anxiety and response mode condition would be related to performance on the learning task, additional comparisons between the MMC and CR groups were made. The means and standard deviations of correct responses on the Familiar and Technical learning materials for low, medium, and high A-State students in the two response mode conditions are presented in Tables 13 and 14, respectively.

Table 13

Mean Correct Responses on the Familiar Learning Materials for Low, Medium, and High A-State Students in the Response Mode Conditions

Groups	A-STATE LEVEL Low	Medium	High
Modified Multiple Choice (n=37)			
Mean	66.79	66.71	66.44
SD	3.09	6.26	3.24
Constructed Response (n=37)			
Mean	68.54	66.73	66.38
SD	1.71	2.97	2.79

Two-factor analyses of variance were calculated on these data. Independent variables in both analyses were levels of A-State (low, medium, high) and response mode conditions (MMC, CR). The students were classified low, medium, and high A-State groups on the basis of their A-State scores during the Familiar materials for the first analysis; on the second

Table 14

Mean Correct Responses on the Technical Learning Materials for Low, Medium, and High A-State Students in Response Mode Conditions

Groups	A-STATE LEVEL Low	Medium	High
Modified Multiple Choice (n=37)			
Mean	159.15	155.30	165.14
SD	17.93	26.24	10.23
Corrected Response (n=37)			
Mean	155.44	149.75	141.40
SD	22.97	18.29	20.82

analysis, students were classified low, medium, and high A-State groups on the basis of their A-State scores during the Technical materials. The dependent measure in the first analysis was mean correct responses on the Familiar materials; mean correct responses on the Technical materials was the dependent measure in the second analysis.

Results of the analysis of variance on the Familiar materials again revealed no significant main effects or interactions. On the Technical materials, results of the analysis of variance indicated that students in the MMC group ($\bar{X}$ = 160.38) made more correct responses than students in the CR groups ($\bar{X}$ = 146.62). This main effect of response mode conditions was significant at the $p < .05$ level ($F = 5.29$, $df = 1/68$). As in the A-Trait analyses, level of A-State was not found to be related to performance on the learning materials for the CR and MMC groups.

DISCUSSION

The findings in the present study which were generally consistent with the predictions of Trait-State Anxiety Theory (Spielberger et. al, 1970) and Drive Theory (Spence, 1958; Taylor, 1956) may be summarized as follows: (a) students who were high in A-Trait responded to the learning task with higher levels of A-State than low A-Trait students; (b) higher levels of A-State were evoked by the more difficult Technical CAI materials than by the easy Familiar CAI materials. Thus, level of A-Trait was found to be related to level of A-State, and higher levels of A-State were associated with the difficult rather than easy sections of the learning materials.

Inconsistent with Trait-State Anxiety Theory and previous CAI studies with mathematical learning materials (Leherissey et. al, In press; O'Neil, Spielberger, & Hansen, 1969; O'Neil, Hansen, & Spielberger, 1969) was the finding that level of A-Trait students performed significantly better than high A-Trait students; whereas, level of A-State was only moderately related to Technical posttest performance ($p < .10$) with a tendency for low A-State students to perform better than high A-State students. The prediction and previous CAI finding that level of A-State rather than A-Trait was related to performance was, therefore, not replicated with the verbal and graphical learning materials used in the present CAI study. A possible explanation for the failure to find a relationship between level of A-Trait or A-State and learning program performance may be the fact that, unlike previous CAI studies (Leherissey et. al., In press; O'Neil Spielberger, & Hansen, 1969; O'Neil, Hansen, & Spielberger, 1969), students were not required to give the correct response

before progressing to the next frame. Thus, the present situation may have reduced the debilitating effects of anxiety on performance.

Consistent with Tobias' findings (Tobias, 1968; Tobias, 1969; Tobias & Abramson, 1970), students were found to perform significantly better on the Familiar section of the achievement posttest than on the pretest. In addition, an interaction was found between response modes and levels of A-Trait on the Familiar portion of the posttest. Whereas low A-Trait students in the Reading and Covert groups performed better than high A-Trait students, for the Constructed Response and Modified Multiple Choice groups, high A-Trait students performed better than low A-Trait students. In order to investigate Tobias' (1968) finding that students in the Reading and Constructed Response groups did not differ in performance on the Familiar posttest, the performance of these groups in the present study was collapsed over levels of A-Trait, resulting in a mean of 16.85 for the Reading group and a mean of 15.22 for the Constructed Response group. This difference was significant at the $p<.05$ level, indicating that students in the Reading group performed better than students in the Constructed Response group on this portion of the posttest.

In addition, Tobias' finding that the Constructed Response group achieved more than the Reading group on the Technical subject matter was not replicated in the present CAI study. That is, it was found that students in the Constructed Response and Reading groups performed at approximately the same level on the Technical portion of the achievement posttest. The present study also found that students in the Covert and Modified Multiple Choice groups performed at approximately the same level, but significantly poorer than the Constructed Response and Reading groups on the Technical posttest.

In order to interpret the finding that the Constructed Response group did not achieve more than the Reading group on the Technical posttest, several other findings must be taken into consideration. First, it was found that students in the Constructed Response group had significantly higher A-State scores during the Technical portion of the learning program and before and during the achievement posttest than the Reading group. It would, therefore, appear that the more complex nature of the Constructed Response mode may have been a more stressful condition than the Reading mode.

The second finding which seems to support this interpretation is that students in the Constructed Response group took nearly twice longer than the Reading group to complete the instructional materials. Furthermore, the present study found that level of A-State was related to learning time, in that high A-State students took longer on the learning task than medium or low A-State students. It thus seems reasonable to suggest that the average time of two hours on the CAI system for the Constructed Response group, associated with higher levels of state anxiety, may have served to depress their posttest performance. The longer learning times for students in the Constructed Response groups also suggests there may have been a greater memory load for this group, resulting in poorer performance on the Familiar posttest as compared to the Reading group.

Another possible explanation for the finding that the Constructed and Technical posttest may be the fact that students in the Constructed Response group were made more hostile by the length of time required to learn the instructional materials. Written and verbal comments by students in the Constructed Response condition tend to support this explanation.

It must also be noted however, that the failure to replicate Tobias' (1968) findings on the Technical posttest may have been due to the fact that the type of practice in "constructing" EKG tracings for the CR group was not directly related to the actual drawing of tracings required on the achievement posttest. That is, whereas students in the Constructed Response groups who learned these materials via PI (Tobias, 1968) drew EKG tracings on both the learning program and posttest via CAI, they only drew them on the posttest in CAI. It will be recalled that in the present study, students in the Constructed Response group for the learning program were presented a mimeographed handout in which each of the different EKG tracings had been broken down into a series of discrete shapes, each of which was associated with a particular number. Thus on the CAI learning program, the EKG tracings were then "constructed" by typing the numbers that represented particular sequences of shapes. Whereas, on the posttest the students, as in the PI version, actually drew the tracings. These differences in procedures may have led to discrepancies between previous PI findings and the findings of the present study.

Also of interest in the present study was a comparison of the relationships between response mode and performance for those students who responded to problems within the CAI learning materials. Neither level of A-Trait nor level of A-State was found to be related to performance on the Familiar and Technical portions of the learning program for students in the Constructed Response and Modified Multiple Choice groups. In addition, it was found that students in the Modified Multiple Choice group performed significantly better than students in the Constructed Response group on the Technical, but not Familiar, portion of the learning program. The latter findings are not particularly surprising in light of

the fact that the number of alternative responses for the Constructed Response group on the Technical graphical learning materials exceeded that of the Modified Multiple Choice group, and thus the probability of a greater percentage of errors for the Constructed Response group would be expected.

In conclusion, the findings of the present study make it difficult to evaluate the absolute effects of response mode conditions on A-State and performance, and point out the importance of taking into account both total time spent on the learning task and level of state anxiety in interpreting the results.

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